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METHOD FOR MEASURING COMPONENT CONCENTRATION OF MULTICOMPONENT LIQUID
[Taseibuneki no nodosokuteihoho]

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Specification /417*

1. Name of this Invention

METHOD FOR MEASURING COMPONENT CONCENTRATION OF MULTICOMPONENT LIQUID

2. Claim(s)

[1] Method for measuring the concentration of each component in a multiple component solution consisting of a mixture of different component liquids, wherein the method for measuring component concentration of multicomponent liquid comprises the steps of: (1) obtaining physical quantity data of respective plural components beforehand for plural kinds of multicomponent liquid samples whose concentration ratio of each component is known, (2) creating data maps describing the correlation between the concentration and physical quantity of each component, and (3) determining the concentrations of components by collating the plural physical quantity data detected from the object multicomponent liquid with the data maps thereof.

3. Detailed Explanation of this Invention

[Technological Field]

This invention pertains to a method for speedily and accurately obtaining the concentrations of multicomponent liquid prepared by mixing a plurality of components.

* Numbers in the margin indicate pagination in the foreign text.

[Conventional Technology]

For measuring the concentration of each component in a multicomponent liquid prepared by mixing different kinds of components, a neutralizing titration method is known. This method takes a multicomponent liquid, which is a measuring object, to a titration cell, dilutes the liquid if needed by adding purified water, and performs titration. To conduct this titration, the inflection points of the pH are obtained by adding a reagent to a fixed quantity of multicomponent liquid, and the concentration of the component is calculated based on the added quantity of the reagent.

[Problems to be Solved by this Invention]

To perform the above-mentioned neutralizing titration method, the titration cell must be sufficiently cleaned prior to placing the multicomponent liquid in the titration cell. Therefore, in addition to the solution-feeding pipe for supplying the multicomponent liquid, a liquid supply pipe is needed for supplying cleaning water (also used as diluting water) to the titration cell. Moreover, as the multicomponent liquid and diluting water are supplied to the titration cell using a pressure (e.g., nitrogen gas), a pressure supply pipe is needed. As a result, the titration system configuration becomes complex. Furthermore, many electromagnetic valves provided to the liquid feeding pipes and pressure feeding pipes need to be opened and closed sequentially in a specific order. Hence, one measurement takes at least 8 minutes (approx.), making

instantaneous measurement impossible. Also, the mechanical parts such as electromagnetic valves tend to create problems. /418

[Object of this Invention]

This invention was developed to solve the above-mentioned problems. The object of this invention is to provide a multicomponent liquid concentration measurement method capable of accurately obtaining the component concentrations in the multicomponent liquid in real time.

[Means to Solve the Problems]

To achieve the above-mentioned object, this invention provides a method for measuring the concentration of each component in a multicomponent liquid prepared by mixing different component liquids, wherein the method for measuring component concentration of multicomponent liquid comprises the steps of: (1) obtaining plural kinds of physical quantity data beforehand for plural kinds of multicomponent liquid sample whose concentration ratio of each component is known, (2) creating data maps expressing the correlation between the concentration and physical quantity for each component, and (3) determining the component concentration by collating the plural physical quantity data detected from the multicomponent liquid, which is a measuring object, with the data maps thereof.

[Operation]

According to the technique described above, once the physical quantity data, such as liquid temperature, sound wave propagation

speed in the liquid, refractive index, etc., are taken in from the multicomponent liquid provided as a measurement object, the value applicable to the measured physical quantity data is selected from the data map of the component which is the object of concentration measurement. Then, by contrasting the measured value with the data on the data map, the component concentration can be instantly obtained.

When the physical quantity data detected from the multicomponent liquid does not match the physical quantity data in the data map, a new data map is created from two kinds of data maps between which the measured data should exist, by providing an interpolating computation using those two kinds of data maps. Hence, the component concentration can be acquired based on this newly created data map.

Hereafter, this invention will be further explained while referring to figures.

[Embodiments of this Invention]

Figure 1 illustrates the component concentration measurement device to which the method based on this invention is incorporated. As shown in the figure, the multicomponent liquid **4** is put in a reaction vessel **3**. By making a web **30** made of aluminum (for example) pass through the liquid, the web surface can be chemically treated by the multicomponent liquid **4**. This multicomponent liquid **4** is prepared by mixing a component **X**, component **Y**, and purified water at a prescribed concentration ratio. When this concentration ratio

changes and exceeds the allowable range, appropriate additive components are supplied from a purified water supplier **5**, component **X** supplier **6**, and component **Y** supplier **7**.

A circulation path **9** equipped with a liquid supply pump **8** is connected to the reaction vessel **3** for circulating a multicomponent liquid **4** by operating the liquid supply pump **8**. A liquid temperature meter **11**, sound speed meter **12**, and refractive index meter **13** are assembled at certain locations in the circulation path **9** in order to measure the temperature, ultrasonic wave propagation speed, and surface refractive factor of the multicomponent liquid **4** traveling the circulation path. The liquid temperature **T**, ultrasonic wave propagation speed **V**, and boundary surface refractive factor **N** respectively obtained from the liquid temperature meter **11**, sound speed meter **12**, and refractive index meter **13** are inputted into the CPU 16 through an A/D converter **15** as the physical quantity data of the multicomponent liquid **4**. Thus, liquid temperature **T**, ultrasonic wave propagation speed **V**, and surface refractive factor **N** are respectively stored in the RAM 18.

The X-ROM 20 and Y-ROM 21 are for storing the data maps **23, 24** (their conceptual illustration are shown in Figs. 2 and 3.) The X data map **23** shows the correlation between the refractive factor **N** and propagation speed **T** of the multicomponent liquid **4** when the liquid temperature **T** of the multicomponent liquid **4** is a known value and concentration value **DX** of component **X** is used as a parameter. This X

data map **23** can be obtained by operating the measurement device shown in Fig. 1 by varying the liquid temperature **T** and concentration value **DY**. Similarly, the Y data map **24** can be created using the concentration value **DY** of the Y component as a parameter.

Considering that the X data map **23** and Y data map **24** are created for every 5°C of the liquid temperature **T**, to create an interpolation map with an interpolation map computation part **27**, the following method is used: If the liquid temperature T is 33°C, for example, its data map is created by interpolatively computing two kinds of data maps (i.e., X data maps **23a, 23b** or Y data maps **24a, 24b**) allowing 33°C to exist between their liquid temperature values. Note that the reference numeral **28** denotes a CRT for displaying the measurement result. Without saying that, in addition to the CRT 28, a printer can be utilized. /419

Hereafter, the process of obtaining the concentration value using the above-mentioned configuration will be explained.

First, the device shown in Fig. 1 creates an X data map **23** and Y data map **24**. To create an X data map **23**, by predetermining the liquid temperature **T** of the multicomponent liquid **4** to 30°C and the concentration of the X component to D1, the refractive index **N** and propagation speed **V** are measured sequentially at every change of concentration **DY** of the Y component, and the obtained physical quantity data are mapped as shown in Fig. 2. Then, whenever the liquid temperature **T** is increased for 5°C, the refractive index **N** and

propagation speed **V** are measured and mapped. Also, for creating a Y data map **24**, the refractive index **N** and propagation speed **V** are measured and mapped in the same sequence using the concentration **DY** of the Y component in the multicomponent liquid **4** as a parameter. These mapped physical quantity data are respectively stored to the X-ROM 20 and Y-ROM 21. After the X data map **23** and Y data map **23** are stored respectively to the X-ROM 20 and Y-ROM 21, the concentrations of X component and Y component in the multicomponent liquid **4** can be measured at the selected liquid temperature and concentration ratio.

To measure the concentration of X component in the multicomponent liquid **4**, the multicomponent liquid **4**, which is the measurement object, is sent through the circulation path **9** by operating the liquid feeding pump **8**, during which respective data (i.e., liquid temperature **T**, sound speed **V**, and refractive factor **N**) obtained from the liquid temperature meter **11**, sound speed meter **12**, and refractive index meter **13** are collected and inputted to the CPU 16. After storing those data to the RAM 18, the CPU 16 refers to the liquid temperature **T** of the multicomponent liquid **4**. If "T = 30°C", the CPU 16 reads out the X data map **23a** from the X-ROM 20 corresponding to "T = 30°C".

After reading out the X data map **23a** in this manner, assuming that the values of measured propagation speed **V** and refractive factor **N** are respectively V_1 and N_1, as shown in the X data map **23a** of Fig. 2, Point **P1** is determined from the values of propagation speed $\mathbf{V_1}$ and

refractive factor **N_1**. Subsequently, the concentration value **DX4** can be determined as the characteristic line to which this Point **P1** belongs. Note that, when the values of propagation speed **V** and refractive factor **N** are V_2 and N_2 respectively, Point **P2** may be positioned at a location outside of the characteristic line of the concentration value **DX** as shown in Fig. 2. However, in this case, by providing an interpolative computation based on the characteristic lines of concentration values **DX3** and **DX4**, the concentration value **DX** can be determined.

The liquid temperature T of the multicomponent liquid **4** may not be within the range of the liquid temperature T of the X data map **23** prepared for every 5°C of liquid temperature **T**. For example, if the liquid temperature **T** of the multicomponent liquid **4** is 42°C, the interpolation map computation part **27** creates an X data map for "T = 42°C" based on the X data map **23c** at "T = 40°C" and X data map **23d** at "T = 45°C". The X data map for "T = 42°C" prepared in this manner is stored in the RAM 18, thereby allowing the acquisition of the concentration value **DX** of the X component by the same sequence. Note that the concentration value **DY** of Y component can be acquired by the same processes.

The measured data obtained as described above is displayed on the CRT 28, thereby allowing the real time acquisition of measurement result. The measurement accuracy of the above-mentioned method is ±2%, satisfying the instantaneousness and precision accuracy. Also,

the changes of the concentration ratio of the purified water X component and Y component constituting the multicomponent liquid **4** can be monitored in relation with the passage of time. Moreover, the operations of the purified water supplier **5**, X component supplier **6**, and Y component supplier **7** can be controlled by feeding back the measured concentration value data.

Although the temperature difference between the maps was set at 5°C in the embodiment described above, it can be a smaller value, as the smaller the value, the higher accuracy can be obtained. However, by reducing the temperature to a smaller value, the memory capacity of the X-ROM and Y-ROM must be increased corresponding to the smaller temperature value. Therefore, the temperature gap between maps is preferably approx. “0.1°C - 5°C”.

This invention was explained above according to the embodiments by referencing to figures. However, other than the liquid temperature, the pH value, specific gravity, conductivity, etc. are also usable as the physical quantity data measurable from the multicomponent liquid. Moreover, when applying this invention, the components composing the multicomponent liquid may be any type of liquid. Also, the multicomponent liquid may contain three or more kinds of components. In addition, the multicomponent liquid does /420
not need to contain purified water.

[Effectiveness of this Invention]

As explained above, with the method based on this invention, a data map expressing the relation between the physical quantities of the components is created beforehand based on the physical quantities measurable from the multicomponent liquid, so that the concentration of component can be determined by collating the physical quantity obtained from the multicomponent liquid (measuring object) with the data map.. Hence, unlike the conventional neutralizing titration measurement method, the measurement can be conducted continuously in real time. Also, the concentration change, which is too small to be measured by the specific gravity value, can be highly accurately detected. Furthermore, since this invention can eliminate the complex device with pipes, the cost can be drastically reduced.

4. Simple Explanation of the Figures

Figure 1 is a diagram of simplified configuration of a meter for performing the method based on this invention.

Figures 2 and 3 are conceptual drawings of data maps used for acquiring the component concentrations.

3….Reaction vessel; 4…Multicomponent liquid; 9…Circulation path; 11…Liquid temperature meter; 12…Sound speed meter; 13…Refractive index meter

Key: 3....Reaction vessel; 4...Multicomponent liquid; 5...Purified water supplier; 6...X-component supplier; 7...Y-component supplier; 5...(Web); 9...Circulation path; 11...Liquid temperature meter; 12...Sound speed meter; 13...Refractive index meter